Baseball

Rules, rules, rules! America's game is sure has a lot of rules: many of them involving the equipment. Baseball is a highly regulated game that opposes most technological improvements in order to uphold the traditions (and statistics). The most telling rules involve the specifications on the ball itself and the bat. The specification for the ball, for example, defines its weight to within a quarter of an ounce and its circumference to within a quarter of an inch. The rule also tells how it must be made and out of what materials. Similarly, the bat rule defines the bat's maximum thickness, maximum length, and the material it can be made out of (wood only in the pros). Several of the questions we will investigate hinge on these rules. So, let's look into the following items of interest:

- What is the 'sweet spot' on a baseball bat?
- Are all bats created equal?
- Why does a curve ball curve?
- How do fielders judge a fly ball's trajectory?
- Why do you pull the glove towards your body as you catch a ball?
- Are there really stadiums where it's easier to hit home runs?

Question 1: *What is the 'sweet spot' on a bat?*

Introduction

If you've ever played baseball you know that hitting the ball wrong can be a painful experience. You also know that the distance you get from a hit is very dependent on where along the bat you make contact. Why? The common explanation is that every bat has a 'sweet spot' which gives the best result when the ball makes contact at that point. This area is defined as the spot which creates no vibrations to the handle when struck by the ball. A ball hit at this point also goes further because more energy is returned to the ball since none is lost to vibration. So where is this spot? Most ball players intuitively know where the sweet spot is because have learned from years of practice. The following experiment will help us lay people fund the sweet spot of the bat.

Equipment Needed

1. Baseball bats
2. Hammers
3. Small nails
4. String

Procedure

1. Have student hold the bat a few inches from the end of the handle between the thumb and the fingertips.
2. Have another student lightly tap the bat at several places along the bat.
3. The student holding the bat should feel for vibrations each time the bat is struck.
4. The sweet spot can be identified by the absence of these vibrations. When you find this spot, mark it on the bat.
5. Now find the center of gravity of the bat by suspending the bat at several points until it balances. This can be done by tapping a small nail into the bat and tying a string to the nail.
6. When you have identified the center of gravity, mark it also.

Analysis/ Questions

1. Are the center of gravity and sweet spot at the same place?
2. This point is also known as the center of percussion. Why?

Question 2: *Are all bats created equal?*

Introduction

The rules of baseball allow substantial variation in the length of the bat (must be no longer than 42 inches) and its maximum diameter (no more than 2 3 / 4 inches) but in professional baseball it must be made of wood. In all other ball leagues aluminum bats may be used. Therefore batters have a lot of leeway in selecting the bat which best fits their style. How do they make this decision? Do they choose the bat that is easiest to swing or the heaviest bat they can swing comfortably? Let's do an experiment which examines this decision.

Equipment needed

1. Bats of several lengths, weights, and of both wood and aluminum
2. Baseballs
3. Measuring tape
4. Ground markers

Procedure

1. Have students swing at least five bats and fill in the table below.

Bat length	Bat weight	Material	Perceived ease of swing

2. Have students bat at easily thrown balls with same five bats. Measure the distance of hit balls for each bat. Hit several ball with each bat so that average distance of hit with each bat can be made.

Analysis/ Questions

1. Which bat was easiest to swing for each student?
2. Can you define a relationship between the physical characteristics of the batter and the bat preferred?
3. Which bat resulted in the best hitting for each student?
4. Can you define a relationship between the batter's characteristics and the most effective bat?

Question 3: *Why does a curve or knuckle ball curve?*

Introduction

There are several pitches in baseball whose trajectories deviate significantly from a parabolic path. These pitches are useful to trick the hitter and keep him/her from hitting safely. However, these pitches are also more difficult to control and are harder to catch. Former major league catcher, Bob Uecker, was asked how to best catch a knuckle ball. In response, he said, "Wait until it stops rolling and pick it up." His reply illuminates the frequency with which a knuckle ball hits the dirt in front of the catcher. But that's good if the catcher traps the ball and the pitch results in a confused batter swinging and missing. Many parameters determine the flight of the pitch. The position of the ball in the pitcher's hand and the delivery technique are among those considerations. Also remember that the baseball is not a uniform sphere. Baseballs have stitches which close the cowhide outer layer. Analysis of these pitches needs to be made so that we can define how they are performed. We will also look at the illegal techniques used to change the flight of the ball and confuse the batter.

Equipment Needed

1. Computer Internet access
2. Books on baseball and sports

Procedure

1. Have students divide into three research groups.
2. Assign one of the following topics to each group: curve balls, knuckle balls, illegal pitches.
3. Research papers should report on how the pitches are thrown, the trajectories of the ball, the grip of the pitcher on the ball, any special delivery techniques needed, and the physics which makes the ball curve.

Question 4: *How do fielders judge a fly ball's trajectory?*

Introduction

Research suggests that the average fly ball is airborne for about 5 seconds from impact to touch down. Outfielders need to judge the ball path and their own position so that they meet the ball as it reaches the ground. Assuming that just starting a run takes about 1 second then the fielder has approximately 4 seconds to run to where he/she believes the ball will end up. Split-second decision making is certainly required to judge the ball, decide where to go, and get there on time. Let's do an experiment to determine which hits are the hardest to field.

Equipment Needed

1. Fungo bat
2. Baseballs
3. Score cards for each fielder

Procedure

1. Have students take turns in center field.
2. Have a fielding coach hit balls into the outfield left, right, and straight at the fielder.
3. The fielder should attempt to run to where they think the ball will land without trying to catch the ball.
4. The fielders are score +1 for meeting the ball within three feet, 0 for failing to come within three feet but running in the correct direction, and -1 for going the wrong way and having to change directions to come back to the ball.
5. Prepare a score card for each fielder. An partial example is shown below:

Hit#	Left	Right	Straight	Score
1	T			+1
2	T			0
3		T		+1
4		T		+1

6. Be sure that several hits are scored for all three directions.
7. Tally the total score for each of the three trajectories. A high total indicates good judgment of flight path.

Analysis/ Questions

1. Do fielders judge all three trajectories equally well?
2. Are some fielders better than others?
3. What characteristics seem to make the best fielder?
4. Factor in the experience in baseball playing of each of your fielders. What conclusion could you reach with this additional information?

Question 5: *Why do you pull the glove towards your body as you catch a ball?*

Introduction

Anyone who have caught balls barehanded knows that to do so can sting. The sting is created by the force of the ball contacting the hands. This effect can be avoided if this force can be reduced. How can this be done? To answer that question we need to look at the physics of forces. Newton tells us how a force is related to the acceleration of a mass in his second law: **F = m * a** where F is the force, m is the mass, and a is the acceleration. Also acceleration is the change in speed over time. Adjusting the equation we get: **F = m * ^{a}v / t** Or we can rearrange this to get: **F * t = m * ^{a}v .** Since mass of the ball and change is speed (you must stop the ball) are predetermined, the right side of this equation is a constant value. So to reduce the force, F, that your hands feel you need to increase the amount of time, t, over which you will catch the ball. One way to do that is to pull the glove towards you as the ball makes contact. Incidentally, this technique is

exactly analogous to a fighter leaning away from a punch, because even if the punch connects the force will be reduced because the time in contact is increased.
But feeling is believing, so let=s do a short experiment.

Equipment Needed

1. Balls
2. Gloves

Procedure

1. Have students take turns catching the ball with and without a glove.
2. Have a pitcher throw medium hard balls to the student fielders.
3. Determine the perceived force on the hands based on catching in each of the four configurations: stiff -armed catch without glove, stiff-armed catch with glove, flexed catch moving in towards body with glove and without glove.

Analysis/ Questions

1. Can you feel the difference in the force of the ball when you catch stiff-armed versus flexed?
2. How does the glove improve your chance of catching the ball and reducing the force?

Question 6: *Are there really stadiums where it's easier to hit home runs?*

Introduction

The rules of baseball do not define the exact size of a baseball field. They do define the minimum length of the left foul line (325 feet) and the distance from the plate to the fence in dead center field (400 feet). Therefore, the actual dimensions of fields vary quite a bit. Not only that, but fields are also different in their altitude above sea level and other parameters which matter. For example, there are some areas of the country where there is a near constant westerly wind . This type of wind would naturally carry balls further into right center field. So we will examine the statistics to determine whether some professional fields encourage home run hitting.

Equipment Needed

1. Sports statistics books
2. Almanac or book of facts to determine characteristics of stadiums

Procedure

1. Assign different stadiums to different students.
2. Have the students research the home run statistics for the stadium as well as the physical characteristics of the stadium.
3. Report the information to the class.

Analysis/ Questions

1. Are there stadiums which enhance the chances of hitting a home run? Why?

2. List the stadiums in order of difficulty.